

3-26-06

U.S. Department of the Interior

National Park Service

**Photomonitoring Protocol for Sensitive Geologic Features at the Craters
of the Moon National Monument and Preserve (CRMO)**

by

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Based on and adapted from:
Photomonitoring Protocol for the Upper Columbia Basin Network by Tom Rodhouse,
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Prepared for:

(Draft) Version 1.00 (March 16, 2006)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	New Version #

Important Note: This sampling protocol consists of this Protocol Narrative and the following Standard Operating Procedures (SOPs):

SOP 1:	Before the Field Season
SOP 2:	Training Observers
SOP 3:	Using GPS Receivers – Creating a Rover Datafile
SOP 4:	Feature Recognition and Photopoint Establishment
SOP 5:	Photography
SOP 6:	Field Procedures
SOP 7:	Photo Archiving
SOP 8:	Data Management
SOP 9:	Data Analysis
SOP 10:	Reporting
SOP 11:	After the Field Season
SOP 12:	Revising the Protocol

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I. Background and Objectives

Rationale for Photomonitoring Sensitive Geologic Features at CRMO

Photographing and monitoring (photomonitoring) of natural features within the confines of the recently extended boundaries of Craters of the Moon National Monument and Preserve (CRMO) are appropriate to the interests of the U.S. National Park Service and Bureau of Land Management. CRMO is a component of the Upper Columbia Basin Network (UCBN) of parks, so an inventory mechanism based on the photomonitoring of sensitive natural features is essential to long-range preservation of attractions and, therefore, the viability of the system. CRMO's existence is based on the manifestation of geologic phenomena, particularly fresh volcanic features younger than 15 thousand years old that undergo natural and human-caused degradation with time. Sensitive geologic features, therefore, ought to be unimpaired for future generations to visit and observe.

Photography and field notations are considered the dominant forms of archived documents related to sensitive geologic features. All such forms must contain information related to the classification and location of pertinent features. Documents without such information, or documents provided without a means to determine either classification or location, are considered irrelevant to the archived inventory. Sources of primary information collected prior to current surveys include old photographs, written reports, and formal publications that contain such information. Anecdotal documents, unless formalized in a report or publication, are considered secondary information to be used at the discretion of the officer in charge of information acquisition and storage. Moreover, photographs and written reports that depict only examples of features without specified locations are essentially useless to the archival inventory process.

Photographs of landscapes, including photographs of specific natural features at all scales, are rich datasets that are accessible to a broad audience and can quickly transmit a tremendous amount of useful information. Historic photographs are particularly valuable because they may contain as much or more information about past environmental conditions than accompanying written material. Photography is a relatively inexpensive and efficient way to capture current landscape conditions and can be easily archived for future reference. It is also unobtrusive, and does not contribute to trampling and the "wear out effect" that can be problematic for other sampling methods. The most powerful application of photography to monitoring involves repeat photography, the art and science of relocating and re-photographing previously photographed scenes.

Repeat photography has been used to identify and track landscape change almost since the beginning of photography in the 19th century. Sebastian Finsterwalder conducted repeat photography surveys of glaciers in Europe during the late 1880's (Rogers et al. 1984). In recent decades, repeat photography has been used to monitor and evaluate change in a wide variety of applications, including glacial retreat in Alaska (Lawrence and Engstrom 1993), change in sagebrush vegetation (Johnson 1984), debris flow chronology and frequency in the Grand Canyon (Webb et al. 2000, Griffiths et al. 2004), fire and vegetation trends in the northern Rockies (Gruell 1983), and demographic changes in cactus of Baja California (Bullock et al. in press). The breadth and depth of the uses repeat photography has been put to for documenting and monitoring

environmental change is extensive. At least two annotated bibliographies have been assembled (Rogers et al. 1984, Hart and Laycock 1996) and a thorough treatment on the methods and materials of photomonitoring was recently assembled by Hall (2002). Based on these works, it is clear that repeat photography can be immediately employed in the CRMO, as well as throughout the UCBN to generate both qualitative and quantitative information about trends and changes in park attractions, geologic features and ecosystems.

This protocol proposes the applications of repeat photography to CRMO, and outlines step-by-step procedures for conducting repeat photography in the CRMO over time. It should be noted that repeat photography is a widely applicable tool which is pertinent to the UCBN vital signs monitoring program. Two different types of repeat photography are applicable to the vital signs program: (1) the use of historical photographs and (2) the establishment of a network of new photopoints where future photomonitoring can occur. Although historical photographs are essential to the program, the protocol for their use is outlined elsewhere and a greater need exists for the latter component of repeat photography. Therefore, the SOPs in this protocol accommodate most applications related to a network of new photopoints. Moreover, although repeat aerial photography and satellite imagery is often used to track trends and changes in UCBN parks, the focus of this protocol is on ground-based photography and the establishment of photopoints appropriate to the scales of human observation.

Historical Development of Repeat Photography in Upper Columbia Basin Network Parks

Historical perspectives of photography are outlined in detail in the *Photomonitoring Protocol for the Upper Columbia Basin Network* by Tom Rodhouse. Much of the previous work on photomonitoring involved the assessment of ecosystems, with particular attention being paid to archeological and biological resources. Historical aspects are treated briefly here mainly to summarize work that is appropriate to CRMO and to the protocol for the inventory of sensitive geologic features. Overall, very little photomonitoring has been conducted in the UCBN. However, a notable exception is the work by Wright and Bunting (1994) at CRMO and more recent efforts by the CRMO staff. Wright and Bunting selected 35 old photographs collected in the monument between 1923 and 1965. Photopoints were relocated and re-photographed between 1986 and 1990 and used to evaluate vegetation change. Through this effort and that of CRMO staff, a network of new photopoints has been established and is re-photographed approximately every 5 years. Two revealing views of City of Rocks National Reserve (CIRO) originally collected in 1868 were re-photographed in 1979 and 1999 by the Third View Project (Klett et al. 2004). Both views show significant change in the amount and type of vegetation as well as in land use practices. Repeat photographs are used as an aid for visitor interpretation at Big Hole National Battlefield (BIHO) and a pair of photographs taken of the battlefield in 1916 and again in 1980 are included in a text on fire and vegetative trends in the northern Rockies (Gruell 1983). Some photomonitoring has also been intermittently conducted by federal and tribal agencies adjacent to UCBN parks. The Bureau of Land Management updates photopoints every 4-7 years as part of its Range Trend Monitoring program in the Preserve portion of CRMO. Some of these photopoints may date back to the 1960s. The agency also maintains some

?
New Monuments

photomonitoring effort in grazing allotments in the CIRO area. The Confederated Tribes of Warm Springs maintains a network of photopoints established in 2000 along Pine Creek, which runs adjacent to the Clarno Unit of the John Day Fossil Beds National Monument (JODA). Relative to the historical and cultural significance of many UCBN parks, modest collections of late 19th century/early 20th century photographs are available for all parks. To date these collections have not been thoroughly evaluated for use in photomonitoring, but many appear promising for this purpose (see the Rodhouse protocol report for an annotated list of archives of UCBN historical photographs).

The work of Wright and Bunting (1994) is significant to CRMO photomonitoring in that it provides most of the significant historical photographs, which have been evaluated for use in studying landscape change. The 1923 photographs of Robert Limbert, the earliest photographer to explore CRMO, are housed in the Boise State University Library special collections on permanent loan from the National Park Service. Nine of the most useful Limbert photographs were used from that collection for the Wright and Bunting survey, although others have been re-photographed by CRMO staff. NPS photographs dating from 1935 and the 1950s and 1960s were also used by Wright and Bunting and are archived in the CRMO museum collections.

Projected Applications of Repeat Photography in Craters of the Moon National Monument and Preserve

Repeat photography is a broadly applicable tool for monitoring environmental change and is well suited for use at CRMO. Following the broader protocol for the UCBN (Rodhouse), the relocation and re-photographing of historic photos will effectively extend the temporal scope of change detection by 100 years or more. Although the protocol for sensitive geologic features is based on specific photopoint sites that are subject to human-caused degradation and long-term natural weathering, general qualitative landscape change detection will be accomplished by the compilation of historic data. The potential for both qualitative and quantitative applications exists, depending upon the quality of the photos and the subject matter contained within the photos. Although the temporal scale may not be completely appropriate for geologic features, Bullock et al. (in press) provide an excellent example of applying a quantitative measure of change in plant demographic rates to historic photos. This potential will be better evaluated for geologic features after the historic photographs available to the CRMO are assembled.

Applications of photomonitoring using newly established photopoints and acquiring new photographs are several-fold and more immediately articulated. Procedures broadly similar to those described by Hall (2002), the UCBN photomonitoring protocol, and others will enable quantitative measurements of geologic resources to be made directly from photos and compared between existing and future photos for change detection. The ability to establish new photopoints beyond those inherited in historic photo collections will allow photopoints to be integrated and co-located with other monitoring program sampling efforts. Important distinctions between protocols for photomonitoring geological features and plant communities (Hall, 2002) are inherent in specifications for field observations outlined below.

Protocol for the field classification and formal documentation of sensitive geologic features within the CRMO must be designed to produce archival information, including imagery and feature descriptions obtained from well-located photopoints. Photomonitoring must provide the basis for continued revisits to sensitive features and the establishment of archival information databases appropriate to geologic features in CRMO and possibly in other NPS and BLM regions.

The documentation of sensitive geologic features is based on the premise that selected features are visible at ground level, exist in sizes on the order of sub-meter to decameter scales, can be accessed by pedestrian and/or vehicular traffic, and are prone to human activity that could result in degradation or removal. Consideration is also given to features that may, over time, become naturally degraded chemically or physically due to atmospheric or surficial geologic processes, and to such processes that may be enhanced by air and water pollution related directly or indirectly to human activities. Photopoints need to be selected that will optimize the repeatability of each location and the documentation of conditions specific to each feature being inventoried.

Measurable Objectives

1. To provide a qualitative measure of landscape change at various scales in the greater CRMO system, extending back 100 years or more where possible.
2. To establish a database of photopoint and photographic information that can be used during subsequent monitoring programs indefinitely.
3. To establish a protocol for photopoint data acquisition, photographic monitoring, and indefinite storage of pertinent information.
4. To determine trends using repeat photomonitoring in degradation effects due to natural processes and human activities within the confines of the CRMO boundaries.

II. Geologic Feature Identification and Photopoint Site Selection

Sensitive geologic features included in the resource inventory must be identified according to classification based on accepted definitions compiled in Appendix C. The list may be continually updated in subsequent version of the protocol as previously unobserved features are discovered or new information is available in the literature. Information that specifies and records the type of formation, mode of occurrence, type locality (if applicable), rarity, and other appropriate information is important to the designation of the feature as being sensitive. If a feature may be identified or classified in more than one category, or there is some ambiguity as to the appropriate classification, an alternate classification must be included in the description. Such features may require additional site visits by other field geologists in order to obtain second opinions or clarify any ambiguity.

Features will be inventoried relative to photopoints, which are specified as the locations from which features are observed and photographed. Spatial scale of the object is an important attribute of geologic features. Several photopoints may be appropriate to

monitoring relatively large features, and multiple photographs may be taken from a given photopoint. Thus, precise photopoint location, compass direction (azimuth) toward photographed object, appropriate scale, and camera properties of each photograph are essential to the photomonitoring process. Photopoints will be located using a GPS (Global Positioning Satellites) receiver and recorded in either standard Latitude – Longitude coordinates or Universal Transverse Mercator (UTM) grid coordinates using the NAD 83 geographic datum (see below). Coordinates must be specified along with any other information that enables the most accurate location for site reoccupation and the translation of location data to other geographic coordinates such as Latitude – Longitude or the State Plane Coordinate system.

Rationale for Selecting this Sampling Design

The use of historic photographs imposes an inherently subjective sampling scheme onto the photomonitoring program in all parts of the UCBN. Most historic photographs were not taken with long-term environmental monitoring in mind and may not be well representative of CRMO sensitive geologic features, or allow for broader inferences. However, several studies have demonstrated the utility of working with historic photographs despite limitations on inference (Webb et al. 2000, Skovlin et al. 2001, Griffiths et al. 2004, Bullock et al. in press). Once all available historic photographs have been evaluated, this situation can be better addressed and included in subsequent versions of this protocol.

Photomonitoring of geologic features inherently involves some level of subjectivity and, therefore, knowledge of such features gained by informal training and formal education. Unlike ecosystem monitoring, which involves grid-based sampling designs appropriate for vegetated areas, geological photomonitoring designs must be based on criteria that are related to sensitivity and accessibility to human traffic. As with other sampling techniques, however, the monitoring objectives and logistical constraints need to be carefully considered. Specific objectives for sensitive geologic feature monitoring are being developed by CRMO and other components of the UCBN. Changes in appearance and dimensions measurable through repeat photography will likely be included in network-wide geologic monitoring objectives. Photomonitoring also has unique logistical constraints related to obtaining good photographs. These constraints will need to be balanced with the overarching sampling strategy and monitoring objectives, and will be detailed in future versions of this protocol.

Site Selection

Photopoints should be selected using three criteria. First, the site should allow for suitable photographs to be taken. Heavy brush and other topographic features should be taken into consideration. Sites not conducive for effective photography should be avoided or evaluated for possible alternative sites from which to photograph the object. Second, anticipation of possible site environmental changes other than feature degradation should be made, and features in dynamic areas, such as those within an active stream channel or adjacent to a live tree, should be avoided or carefully considered. This will help minimize loss of photographic sampling sites to erosion and other disturbances over time. Third, and ultimately, photomonitoring sites should be selected according to the goals of

sensitive geologic feature monitoring, as outlined in this monitoring plan and accompanying SOPs.

Sampling Frequency and Replication

As above, frequency and replication issues will be addressed once objectives have been defined. In general, photographs can be collected multiple times per year, annually, or over longer intervals, depending on the nature of the feature. Most likely repeat photography frequencies for sensitive geologic features will be terms of years or decades, unless rationale, such as anticipated increase in human activity dictate shorter time intervals. Because photography is relatively cheap and easy to collect, necessary replication should be straightforward if the objectives and protocol are well developed. Photographs can be considered data sets to be incorporated into the database of photopoint location information and other pertinent information related to the feature.

III. Field Methods

Glossary of Key Terms

Photopoint-The photopoint is the objective point in the center of the photograph around which the central topic of the photo is concentrated. This should normally be marked in a photograph by a meter board. The photopoint must be permanently marked, usually with rebar or metal fence posts, so that future photographs can be collected with the same spot. ~~camera distance.~~

Camera Station-This is the point from which photographs are taken. Multiple photopoints can be monitored from one camera station, typically in the four cardinal directions. An azimuth is used to describe the line between a camera station and a photopoint.

Corrected for declination
Dimensions: At least three measurements of size will be recorded, usually width, length and height, that adequately describes the dimensions of the feature. All measurements will be in metric units recorded to the nearest centimeter for dimensions up to several meters, and to the nearest meter for larger features. Estimated or paced dimensions are acceptable where direct measurements are physically impossible, dangerous, or will damage the feature.

Spatial orientation: The azimuth of elongate features, such as cracks, fissures and channels, will be recorded using a Brunton compass or equivalent. Azimuth data will be recorded in degrees from north viewed in the direction from one end of the feature, with a notation of quadrant direction from that point (NNE, WSW, etc.).

leads examples for each category
Fragility: Susceptibility to damage or removal will be recorded qualitatively using abbreviations for very low (VL), low (L), medium (M), high (H), and very high (VH).

Human impacts: Noticeable effects of human presence will be recorded, including research marks such as drill holes or sample removal, graffiti, social trails, ATV tracks, litter, campsites, and any other impact that represents temporal change to the feature.

NO!

*We don't want to be pounding fence posts into the features we want preserved.

Mark
Camera
Station
with
stake

corrected
for declination
Note if measurement is
suspect due
to magnetite
content of
basalt.

Image Resolution: All photographs will be taken with sufficient resolution to provide an assessment of conditions relevant to the sensitivity of the geologic feature to degradation and its reason to be monitored. Photographs must be in focus to the average human naked eye. The minimum allowable resolution will be 1000 pixels across the longest dimension of the geologic feature in the focused image. Enlarged parts of the feature may be made by cropping the primary image, as long as the subset region maintains the minimum resolution of 1000 pixels across the longest dimension and the cropped image remains in focus to the naked eye. Digital photography is preferred in order to quickly provide an electronic image suitable for the database. Film photography is acceptable as long as the developed image (transparency or print) is scanned to digital format with clarity that meets or exceeds the minimum resolution allowed. This applies also to the use of older photographs to be scanned and included in the feature database.

Photographic scales: A high-contrast scale that is not an intrinsic part of the geologic feature being observed will be included in all photographs to illustrate relative size. Standard Geological Society of America photographic scales, or equivalent scale of 10 – 20 cm size, may be used for relatively small features. Two-color painted staffs, ranging from 1-meter size and up are appropriate scales for larger features. Human subjects, visible hands, feet, etc., may be included in images for scale; however, a staff or other acceptable scale must be visible that clearly illustrates dimension in units (usually cm or m) appropriate to the size of the feature. All scales will have a two-color high-contrast pattern (black/white generally) such that major and minor divisions are depicted as color changes. One end of the scale will be marked at several minor intervals one-tenth the length of the major interval (e.g. decimeter divisions at one end of a 2-meter stick). At least one indication of the major interval length value must be visible in the photograph or obvious to the viewer. Objects that require text interpretation of scale such as coins, knives, pencils, backbacks and the like, are unacceptable unless accompanied by an appropriate two-color scale.

Camera Settings: Photographs must be taken with camera attributes that maximize clarity, focus and visibility of the feature being recorded. Shadows and other interferences must be minimized, if possible, by adjusting camera settings or lighting (see below). Shutter speed will be no slower than 1/125 second, unless the image is taken using a stable tripod and cable shutter-release (or time-delayed shutter release) to avoid camera movement during exposure. The F-stop on the camera lens will be adjusted to an aperture no greater than F-8 in order to optimize depth of field. Higher F-stop settings (smaller apertures) are preferred. In all cases the lens aperture must provide in-focus exposure of the entire feature. Automatic settings are allowed as long as the shutter speed and F-stop are recorded, and they meet or exceed these minimum protocols.

Weather and lighting conditions: Conditions affecting photographic exposure level, natural lighting, lighting enhancement, or uncertainty of photographic quality for any reason must be recorded. Type and amount of cloud cover and precipitation must be described in full or with abbreviations used in public media. Geologic features covered by snow, rain or vegetation are not acceptable subjects to be photographed unless the degree of cover has little or no bearing on feature interpretation. Lighting conditions must include sun intensity (full, partial, diffuse, etc.), sun angle measured from the horizon, and sun azimuth position at the time the feature is photographed. Natural

lighting must be used whenever possible, even if the time-of-day must be adjusted to accommodate the exposure. Artificial lighting by flash or continual illumination is acceptable only if the feature cannot be photographed otherwise and the lighting conditions can be described in detail.

Date and time: The date and time of each feature photograph will be recorded in standard formats: MM-DD-YYYY and HH:MM, respectively, and based on a 24-hour clock. Appropriate time zone and time period will be noted using standard abbreviations (MST, MDT, etc.) or in Greenwich Meridian Time (GMT). Readings recorded by the GPS receiver are most acceptable; however, a wrist or pocket chronometer is acceptable if in good working order and known to be accurate within five minutes of actual time.

Photopoint Establishment and Relocation

There are two general types of photopoints: general landscape and topical (Hall 2002). Determining which type of photopoint to establish must be driven by the specific monitoring objectives. For example, general landscape photos are typically more suitable for monitoring qualitative landscape change. Repeat photography with historic photos will almost always be of the landscape type. Landscape photopoints may have quantitative applications. Monitoring demographic changes in *Artemisia tridentata*, for example, may be best achieved with landscape photos. However, meter boards are often not used with landscape photos and size control may become a problem for quantitative monitoring applications. Topical photopoints will be the most common photopoint type used in the UCBN monitoring program. These typically are focused on a specific vegetation or morphological subject, and use of a meter board provides effective size control (Hall 2002).

Geologic features and other physiographic features are typically mapped and stored in GPS database files as either points, lines, or polygons. Photopoint locations for sensitive geologic feature photomonitoring will be recorded always as points measured by GPS within 2 – 5 meter uncorrected field accuracy, along with any indication of data correction method that is immediately or subsequently applied to field-acquired positions. Field data will be compiled, either manually or by electronic transfer (preferred), to a digital database (see below) that can be displayed and analyzed using Geographic Information System (GIS) software. Position data will be recorded only when the current GPS positional dilution of precision (PDOP) is 6 or less, or when the viewable satellite configuration positional accuracy falls in the range noted above. Field recorders that provide digital data input may be used with appropriate GPS data dictionaries based on the acceptable feature classification list.

Once a sampling design has been established and suitability of the site for photography has been determined, the most important requirement for establishing new photopoints intended to allow quantitative measurement of vegetation and stream bank morphology is to maintain the exact distance between the camera and the photopoint itself. Each subsequent photograph should be taken from the same point and at the same distance to the meter board. In order to achieve this, initial location and establishment of photopoints, camera stations, and witness sites should be carefully considered (see

Photopoint Establishment SOP). Stability or persistence of sites and features and potential camera view obstructions are particularly important issues. Ability for persons other than those who initially established the photopoints to relocate points is also critical. The location of photopoints, camera stations, and witness sites must be carefully recorded and permanently marked with metal stakes or rebar and aluminum tags or rebar caps. Bearings and distances between these three spots must also be carefully recorded. All locations should be identified to the nearest meter using a GPS set to Universal Transverse Mercator (UTM) coordinates. The horizontal datum currently used in the UCBN is the North American Datum of 1983 (NAD83). This is subject to change and should be noted in subsequent versions of this protocol. Other location information, including detailed directions to the witness site, should be recorded, along with a brief description of the photopoint topic. Photograph copies and accompanying location and orientation information should be organized into a site locator fieldbook. The fieldbook should be updated following each field outing and as new photographs are developed. Simple 5"x5" cardstock with a single ring binder works well, and 3"x5" photographs can be pasted to pages and laminated. The fieldbook will then be useful for relocating points and stations. Permanent marker can be used to annotate photographs and all location information can be included on the back of each page. Photographs used in field books must be copies. Original photographs and negatives should remain in the UCBN archives (see Photo Archive SOP).

Field Equipment and Photographic Methods

Field equipment: Tools used to monitor sensitive features, by logging and photographing, will include everything necessary to accurately and efficiently record archival information (outlined below). These tools generally will include: steel tape measure or folding rule, field notebook or pre-printed datasheets, digital and 35mm film cameras (see Photographic Protocols below), photographic scale, GPS receiver, and a Brunton compass or equivalent. Each entry of a logged and photographed feature into the database will have a record of the type and make of each piece of equipment used in the process.

High quality photographic equipment that allows the user to control film and focal length is essential for both qualitative and quantitative applications of photo monitoring (Hall 2002). Ideally, equipment used in the UCBN will be identical for each successive photographic field effort. Over time, this may not be possible however, so the key parameters of film type, film and shutter speed, f-stop, and focal length must be controlled. Analysis of change between photographs will be much easier, however, if all variables, including camera format, make, and model, are duplicated exactly each time. This information is rarely available for historic photos. Use of a polaroid camera can be helpful with the iterative process required to duplicate the exact position and aim of the original camera. Regardless, all of these variables must be carefully recorded for each new photographic session. The use of digital cameras complicates this considerably.

Many of the important photographic variables are harder to control with a digital camera. The rapid development of digital technology, including storage media, makes this an inherently unstable technology that may not be easily duplicated in 10-20 years. Currently, the UCBN photomonitoring program uses both film and digital cameras at each camera station and duplicates each photopoint. This will allow for evaluation of the technology and future flexibility. In the case of digital cameras, key parameters are focal length, camera processing unit ("speed"), and resolution (dots-per-inch or dpi; usually described in megapixels) (Hall 2002). Other variables that should be controlled include the exact make and model of camera, and the post-processing equipment used to display, store, and print the digital camera imagery.

Camera height must also be consistent between successive photographs. This is best achieved with the use of a tripod. Camera height can vary between photopoints, in order to accommodate the topic of interest, topography, and field of view. However, once the height is established during the first photographic session, this must be maintained in all future photographs of that particular photopoint. Camera height, focal length, and distance to meter board make up the essential geometry of successful quantitative photomonitoring. The camera height should not exceed 5 feet so as to remain accessible to field personnel of short stature.

Because photomonitoring in the UCBN, an arid region, will be conducted in well-lit areas, ISO 100 speed film should be used in most instances. This will provide fine-grained images suitable for enlarging and aid in analysis of subject matter. ISO 64 film would provide even higher quality images but is sensitive to overcast lighting. A digital camera equivalent to ISO 100 is approximately 4.1 megapixels (2280x1800 dpi). At the time of this protocol version, the UCBN is using slide film because of its advantages in storage, ease of scanning, and ability to be projected. This is subject to change following pilot work planned for 2005 and will be addressed in future versions of this protocol.

A 35 mm or 50 mm lens will work well for photomonitoring, although once established, should not be changed between successive photographs (Hall 2002). Consistent focal length is important, and complicates comparison of photographs if focal length varies. Consistent focal length is harder to control with digital cameras, and very difficult to duplicate film camera focal length. Zoom lenses should be avoided. Both black-and-white and color film are useful in photomonitoring and both have advantages. Black-and-white film is more stable over time and permits flexibility in the processing stage. However, color film may enhance interpretation and precision of analysis. An ideal situation is to collect both black-and-white and color photographs each time. Currently, the UCBN uses black-and-white film and a color digital camera. Film type, brand, and ISO rating all must be recorded at the time of photo collection. Brand is particularly important for color film, as different manufacturers use different film chemistry which can influence the color of vegetation (Hall 2002).

The f-stop setting, once established, should be duplicated during each successive photograph. The f-stop controls the aperture opening that admits light in to the camera and exposes the film. The smaller the f-stop, the larger the opening, permitting more light, and requiring a faster shutter speed. Larger f-stops, yielding smaller apertures and longer exposure time, yield a greater depth-of-field (in-focus distance), a desirable goal which will aid in photo analysis.

Finally, the timing of photographs should be carefully considered within the context of the overall monitoring objectives. Certain seasons may not be suitable. For example, winter photography may be most useful for monitoring stream bank morphology because of less vegetation obscuring the field of view. Likewise, questions pertaining to grazing effects may require photos to be collected both prior to livestock turn-out and after livestock have been removed from a site. As with most of the other variables considered above, once the season(s) is established, this should be maintained in future photography. This is important not only for the photographic topic, but also for consistent angle of the sun and shadows produced in the photopoint plot. Time of day influences this as well, and every effort should be made to duplicate the approximate time of day, within 1-2 hours (Hall 2002).

Collecting Ancillary Data – Field Datasheets

Date, camera station number, photopoint number, and other essential information required to manage incoming photographs must be collected systematically each field session. The use of a photograph identification card, visible within the camera view, is an effective way to do this. A dry-erase board or card stock clipped to a stake or other stable but removable tool works well. Hall (2002) recommends that light blue or gold background helps with visibility in black-and-white photographs. In addition to photograph identification information, a detailed site description, including site location and directions to the site are essential. The Field Methods SOP outlines these procedures in detail. Sample data forms are included in Appendix B. Additional ancillary data collection will be driven by monitoring objectives. Most likely, information on vegetation will be required. Other information will include site features, such as slope and aspect. In situations where photomonitoring is co-located with other sampling activities, such as vegetation transects or bird point counts, additional information will be required and will be outlined in future protocols.

Field Season Preparations, Field Schedule, and Equipment Setup

Preparation saves time and money and reduces frustrations encountered in the field. Appendix C contains a comprehensive list of field equipment. Assembling items on this list and reviewing the SOPs well in advance of field sessions will help the UCBN photomonitoring program achieve its goal of providing rich qualitative and quantitative data sets (photographs) in an efficient and cost-effective manner. Camera equipment, GPS units, and other expensive technological equipment should be thoroughly examined early enough so that any necessary repair or replacement can be done before the scheduled field session. Also, careful consideration should be given to other monitoring field activities that can be accomplished during the same field session and preparations made accordingly.

The site locator fieldbook(s) will need to be readied for field use. Ensure that all photopoints and witness sites are represented in the fieldbook with photograph copies and detailed site descriptions and directions. Review the contents of the UCBN photo archive to ensure that all originals are accounted for and properly stored. This process should be repeated following field work to ensure that all new information is properly incorporated into the fieldbook, project database, and that newly developed photos are properly archived. Photomonitoring field work is a two-person job, and both field personnel should have the necessary training to conduct all tasks, including navigation to

photopoints, and ability to use the GPS, camera equipment, and collect all necessary ancillary data. This will increase the efficiency and accuracy of the field effort. Travel time to and from photopoints varies according to terrain and accessibility, however, once at a station, the team should expect to spend approximately X minutes setting up the meter board, taking photographs, and collecting ancillary data.

IV. Data Management [To be Developed]

Overview of database design

Data entry, verification and editing

Metadata procedures

Data archival procedures

V. Analysis and Reporting [To be Developed]

Recommendations for routine data summaries and statistical analyses to detect change

This section will include instructions for conducting grid intersect analysis and computation of demographic rates, after pilot effort.

Recommended report format with examples of summary tables and figures

Recommended methods for long-term trend analysis (e.g., every 5 or 10 years)

This may include regression or time-series type analysis of mean percent cover and demographic rates. It may also include plots of sample variance, rather than means, as another trend statistic.

VI. Personnel Requirements and Training [To be Developed]

Roles and Responsibilities:

Qualifications and Training:

Compass

GPS

Cameras

Plant Identification

VII. Operational Requirements [To be Developed]

Annual Workload and Field Schedule

Facility and Equipment Needs

Startup Costs and Budget

Estimated Costs		
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Field Work (Salary)		
Field Work (Travel)		
Data Management/Reporting (Salary)		
Startup Equipment Costs		
Annual equipment/supplies		
Total		

Procedure for Revising the Protocol and Archiving Previous Versions of the Protocol

Over time, revisions to both the Protocol Narrative and to specific Standard Operating Procedures (SOPs) are to be expected. Careful documentation of changes to the protocol, and a library of previous protocol versions are essential for maintaining consistency in data collection, and for appropriate treatment of the data during data summary and analysis. The MS Access database for each monitoring component contains a field that identifies which version of the protocol was being used when the data were collected.

The rationale for dividing a sampling protocol into a Protocol Narrative with supporting SOPs is based on the following:

- The Protocol Narrative is a general overview of the protocol that gives the history and justification for doing the work and an overview of the sampling methods, but that does not provide all of the methodological details. The Protocol Narrative will only be revised if major changes are made to the protocol.
- The SOPs, in contrast, are very specific step-by-step instructions for performing a given task. They are expected to be revised more frequently than the protocol narrative.
- When a SOP is revised, in most cases, it is not necessary to revise the Protocol Narrative to reflect the specific changes made to the SOP.
- All versions of the Protocol Narrative and SOPs will be archived in a Protocol Library.

The steps for changing the protocol (either the Protocol Narrative or the SOPs) are outlined in SOP #12, "Revising the Protocol". Each SOP contains a Revision History Log that should be filled out each time a SOP is revised to explain why the change was made, and to assign a new Version Number to the revised SOP. The new version of the SOP and/or Protocol Narrative should then be archived in the UCBN Protocol Library under the appropriate folder.

VIII. References

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Appendix A. Field Data Sheet

Appendix B. Checklist of field equipment

Camera Equipment:

Single Lens Reflex (SLR) Film Camera

35 mm and/or 50 mm Lens

ISO 100 Black-and-White Slide Film

ISO 100 Color Slide Film

$\geq$ 4.1 Megapixel (or higher) Digital Camera

~~CompactFlash Cards or other storage media~~

~~Camera Tripod~~

Photopoint Equipment:

1 and/or 2-m Meter Board

30-m Reel Measuring Tape

Rebar or Stamped Metal Fence Posts

Orange Spray Paint

Aluminum Tags

Engraver

$\frac{4}{5}$ lb. Hammer

Ancillary Equipment:

PDA (Dell Axim) w/Database

GPS

Compass w/inclinometer

Photo Identification Board

Photo ID Board Post

Dry Erase Markers

Site Locator Fieldbook

Plant ID Guide/Key

Field Notebook (Rite-in-Rain)

Rite-in-Rain Pen

with base
focal length
of zoom being
35 mm equivalent

for use
in digital
camera

Appendix C. Definitions of Geologic Features

